

What is claimed is:

1. A system for processing a workpiece, comprising:
  - 5 (A) a plasma immersion ion implantation reactor, comprising:
    - (1) an enclosure comprising a side wall and a ceiling and defining a chamber;
    - (2) a workpiece support pedestal within the chamber having a workpiece support surface facing said ceiling and defining a process region extending generally across said wafer support pedestal;
    - (3) gas distribution apparatus for introducing a process gas containing a first species to be ion implanted into a surface layer of said workpiece;
    - (4) an inductively coupled source power applicator;
    - (5) an RF plasma source power generator coupled to said inductively coupled source power applicator for inductively coupling RF source power into said process zone;
    - (6) an RF bias generator having an RF bias frequency and coupled to said workpiece support pedestal for applying an RF bias to said workpiece;
  - 25 (B) a second wafer processing apparatus;
  - (C) wafer transfer apparatus for transferring said workpiece between said plasma immersion ion implantation reactor and said second wafer processing apparatus.

30 2. The system of Claim 1 wherein said second wafer processing apparatus comprises a cleaning species source plasma reactor comprising:

- (1) a source of cleaning species precursor gases;
- 35 (2) a passage coupling said cleaning species source plasma reactor to said plasma immersion ion

implantation reactor.

3. The system of Claim 2 wherein said cleaning species precursor gases comprise a fluorine-containing  
5 species.

4. The system of Claim 2 wherein said cleaning species precursor gases comprise a hydrogen-containing species.

10 5. The system of Claim 1 wherein said second wafer processing apparatus comprises:

an optical metrology chamber for obtaining a measurement of ion implantation in a workpiece;

15 a process controller coupled to receive measurements from said optical metrology chamber for controlling said plasma immersion ion implantation reactor.

6. The system of Claim 1 wherein said second wafer processing apparatus comprises:

20 an ion beam implantation apparatus for ion implanting a second species into said surface layer of said workpiece.

7. The system of Claim 6 wherein said surface layer is a semiconductor material, and said first and second species are dopant impurities of opposite conductivity types relative to said semiconductor material.

8. The system of Claim 1 wherein said second wafer processing apparatus comprises:

30 a second plasma immersion ion implantation reactor for ion implanting a second species into said surface layer of said workpiece.

35 9. The system of Claim 8 wherein said surface layer is a semiconductor material, and said first and second

species are dopant impurities of opposite conductivity types relative to said semiconductor material.

10. The system of Claim 1 wherein said second wafer  
5 processing apparatus comprises an anneal chamber.

11. The system of Claim 1 wherein said second wafer processing apparatus comprises:  
a photoresist strip chamber.

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12. The system of Claim 1 wherein said second wafer processing apparatus comprises a wet clean chamber.

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13. The reactor of Claim 1 wherein said RF bias frequency is sufficiently low to enable ions traversing the plasma sheath to attain an energy corresponding to a peak-to-peak voltage of said bias power generator.

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14. The reactor of Claim 13 wherein said RF bias frequency is sufficiently high to limit RF voltage drops across dielectric layers on said workpiece support pedestal to less than a predetermined fraction of plasma sheath voltage near said workpiece support.

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15. The reactor of Claim 14 wherein said predetermined fraction corresponds to about 10%.

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16. The apparatus of Claim 1 wherein said RF bias generator has a bias RF frequency that is sufficiently low for ions in a plasma sheath near said workpiece to follow electric field oscillations across said sheath at said bias frequency.

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17. The apparatus of Claim 16 wherein said bias RF frequency is sufficiently high so that RF voltage drops across dielectric layers on said workpiece do not exceed a

predetermined fraction of the RF bias voltage applied to said workpiece support.

18. The apparatus of Claim 17 wherein said  
5 predetermined fraction corresponds to about 10%.

19. The apparatus of Claim 1 wherein said RF bias generator has a bias frequency between 10 kHz and 10 MHz.

10 20. The apparatus of Claim 1 wherein said RF bias generator has a bias frequency between 50 kHz and 5 MHz.

15 21. The apparatus of Claim 1 wherein said bias generator has a bias frequency between 100 kHz and 3 MHz.

22. The apparatus of Claim 1 wherein said bias generator has a bias frequency of about 2 MHz to within about 5%.

20 23. A system for processing a workpiece, comprising a plurality of plasma immersion ion implantation reactors, each of said plasma immersion ion implantation reactors comprising:

25 (1) an enclosure comprising a side wall and a ceiling and defining a chamber;

(2) a workpiece support pedestal within the chamber having a workpiece support surface facing said ceiling and defining a process region extending generally across said wafer support pedestal;

30 (3) gas distribution apparatus for introducing a process gas containing a first species to be ion implanted into a surface layer of said workpiece;

(4) an inductively coupled source power applicator;

35 (5) an RF plasma source power generator coupled to said inductively coupled source power applicator

for inductively coupling RF source power into said process zone;

(6) an RF bias generator having an RF bias frequency and coupled to said workpiece support pedestal for applying an RF bias to said workpiece.

24. The system of Claim 23 further comprising a wafer handling apparatus coupled to each of said plurality of plasma immersion ion implantation reactors.